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CORN-BASED PLASTICS: WAVE OF THE FUTURE OR A RIPPLE THAT DEGRADES?

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In 1986, the U.S. generated 1,307 pounds of post-consumer residential and commercial solid waste for every man, women, and child (1, pg. 202). Only 17 percent of this waste was recovered for further use or processed for energy recovery (1, pg 202). Landfill charges for disposing of the remaining 83 percent currently vary from $20 to $120 dollars per ton depending on the region -- the midwest is the cheapest while the east coast is the highest (2). Charges have increased dramatically from the range of $3 to $28 per ton in 1975 (2). Furthermore, by the year 2000, over half of U.S. cities may run out of landfill space, a future foreshadowed by the 162-day odyssey of an Islip, New York garbage barge (3).

Plastics have been singled out as a major culprit in the growing waste disposal problem. They are the fastest-growing component of solid waste: from 0.5 percent of net residential and commercial solid waste discard by weight in 1960 to 7.3 percent by weight in 1986 (1, pg. 202). Compounding the problems created by this rapid growth, only one percent of gross plastic wastes were recovered in 1986 (1, pg. 203), and plastics are estimated to take up to 400 years to degrade (4). In addition, a recent analysis suggested that, due to the low weight of plastics, they compose 32 percent of the volume of waste (5, pg. 282).

Concern over plastic waste has prodded governments to act. Suffolk County, New York banned polyethylene grocery sacks and polystyrene and polyvinyl chloride fast food packaging as of July 1989 (6). In July 1990, Minneapolis, Minnesota will require that food packaging be recycled, reused, or degrade naturally, unless no easy alternative exists (6). Berkeley, California and eleven states also have passed laws concerning non-degradable plastics (6 and 7). Thrity other states are considering legislation (8). Illustrating international concern, Italy will require degradable packaging and wrapping after 1989 (7).

The environmental concern over plastics and associated legislative activity has created a market for degradable and recyclable plastics. Degradable plastics include biodegradable corn-based and photodegradable petrochemical-based plastics. Constraints and opportunities for these options are discussed.

BIODEGRADABLE PLASTICS

Although the specific scientific definition of biodegradable plastics is being debated (9), biodegradable commonly is applied to plastics that degrade through the actions of living organisms. While conventional petrochemical plastics will eventually biodegrade, the term "biodegradable plastics" is usually reserved for plastics that contain starch derived from a farm commodity. Theoretically, plastics can be manufactured from 100 percent of any commodity starch. However, current economic and physical performance considerations dictate use of a mixture that is 6 percent corn starch and 94 percent conventional petrochemical resin and normal additives, such as color concentrate.

Biological organisms degrade the corn starch in a relatively short time, leaving holes in the polymer chain of the biodegradable plastic. As with traditional petrochemical plastics, 400 years may be required for biodegradation of the petrochemical component of a six percent corn starch plastic (10). To take advantage of the increased surface area left by decay of the corn starch, a chemical catalyst is added to the corn starch-petrochemical plastic mixture (4). It is this combination of biodegradation and chemical degradation that reduces the time of decay for corn-based plastics to between 6 months and 2 years (11 and 12), with the exact period of decay dependent on the environment within the landfill.

The most common biodegradable plastic products are plastic bags and agricultural mulch films. The latter are used primarily to deter weed growth in truck crops. Biodegradable plastic bags are estimated to cost 6 to 20 percent more at the manufacturer level than conventional plastic bags (13 and 14, pg. 5). As more biodegradable bags are produced, this cost difference may decrease due to economies of larger production. On the other hand, starch generally reduces the strength of the plastic product (14, pg. 5). One method to compensate for loss of strength is to increase the amount of conventional petrochemical resins (14, pg. 5). Other compensation methods include varying resin composition and/or changing the manufacturing technique (15, pg. 1). These methods may increase the cost of the biodegradable plastic product.

Several concerns confront biodegradable plastics. One is the unpredictability of degradation in a landfill. For example, a study found that a piece of supposedly non-degradable plastic had decomposed 50 percent in 20 years, while a chicken leg next to it still had meat left on the bone (16). Landfill degradation is unpredictable because of the complex interactions among the 36 variables that affect degradation (16). Consequently, the microenvironment of a landfill may substantially retard the rate of decay of corn-based plastics. One specific concern has been whether biodegradable plastics will degrade in an atmosphere that has no oxygen (anaerobic conditions). However, recent research conducted by the

University of Missouri found that corn-based polyethylene plastics degraded in an anaerobic waste treatment plant (5, pg. 283).

A second concern is that residues left by degradation of plastics--of any type--may be toxic to the environment. Measurement of this concern is difficult because most plastic waste has degraded little over the relatively short time that plastic products have been used. The potential for more rapid decay of corn-based plastics makes the possibility of toxic residues a more immediate concern. One recent study found that, under anaerobic conditions, a six percent corn-based polyethylene plastic decayed into natural, nontoxic 25-carbon waxes, which are like those that form naturally on apples (5, pg. 283). Other additional research is currently being conducted on the residue question.

Another concern is the volatility of corn starch prices. Between 1978 and 1988, the standard deviation of annual corn starch prices was 46 percent of the average 1978-1988 price. The comparable ratio for petroleum prices was 29 percent. Manufacturers generally prefer inputs that have greater price stability. However, suitable marketing strategies could probably reduce the problems created by the price volatility of corn starch.

PHOTODEGRADABLE PLASTICS

A chemical can be added to petrochemical plastic resins to trigger degradation once the chemical is exposed to ultraviolet light for a given period of time. These plastics can be targeted to degrade over a length of time between 30 days and one year (17, pg. 53).

Most polyethylenes are inherently photodegradable (18), but, depending on end use, other photodegradable plastic products range up to 20 percent more expensive than comparable non-photodegradable plastics (17, pg. 53). As with biodegradable plastics, costs may decline with improvements in technology and as more photodegradable plastics are produced.

Photodegradable plastics offer a potential solution for litter scattered on the ground. However, because ultraviolet light is readily absorbed by water and earth, photodegradable plastics probably possess limited ability to decompose in landfills if placed immediately in the landfill. Photodegradable plastics may degrade in landfills if exposed to ultraviolet light for a predetermined period of time before being placed in the landfill, but this claim awaits additional research.

RECYCLED PLASTICS

Use of recycled plastics is currently limited by questions about the durability of recycled plastics after repeated reheating and remolding. Also, collection costs are high because of the use-and-discard mentality of Americans and the wide variety of plastic resins. The latter means plastic waste must be sorted into resin groups. Furthermore, many plastic products are made from two or more resins. No economically competitive process currently exists to separate a mixed-resin plastic into its constituent resins (19, pg. 412). Mixed-resin plastics can be recycled only into dark-colored, low-end products that do not require a smooth finish. Markets for these products, such as plastic filler and wood, are limited (19, pg. 412).

Despite these constraints, economic incentives currently exist for recycling some plastics. For example, recycled polyester and polyethylene sell for about half the price of virgin resins (20). Polyester and polyethylene, the most commonly recycled resins, are used primarily in soft drink containers and packaging. Just over 1 percent (222 million pounds) of these resins were recycled in 1987 (20). However, given the abovementioned constraints, potential market share for recycled polyester and polyethylene is estimated at only 4 percent (19, pg. 412 and 20).

Efforts are underway to solve some of the problems that limit the effectiveness of recycling. To aid identification of resin types, the plastics industry has instituted a voluntary labeling system (21). Companies such as Proctor & Gamble are investing in the development of recyclable plastic products (6). A novel potential solution to the problems with recycling is to retrieve the oil contained in plastic products (7).

CONCLUSIONS, MARKET PROJECTIONS, AND SUGGESTIONS

The preceding discussion suggests that, based on current technology and petrochemical resin prices, corn-based biodegradable plastics and most plastics that photodegrade are not priced competitively with traditional petrochemical plastics. Recycled plastics have a price advantage compared with traditional petrochemical plastics, but markets and uses are currently limited by the heterogeneous mixture of resins in the plastic waste stream. Thus, the widespread use of biodegradable, photodegradable, and recycled plastics will require legislation, technological advances, and/or higher landfill charges. Relative to the latter, the incentive to use degradable plastics or recycled plastics could be substantially increased by charging for the landfill disposal of waste on a volume, instead of weight, basis.

The preceding discussion suggests caution in estimating the size of the currently viable markets for corn-based plastics. Biodegradability is probably not a desirable product characteristic for many current uses of plastics, such as in building supplies, transportation, and electrical/ electronics uses. Thus, the major immediate market for biodegradable plastics is probably limited to the packaging market. Packaging accounted for about 14 billion pounds of plastic resins in 1988 (22, pg. 117).

If a six percent corn starch mixture was used for all plastic packaging, an optimistic estimate given the preceding discussion, approximately 25-30 million bushels[1] of corn or about 0.3 percent of 1988 crop year disappearance (23, pg. 46) would be required. Using a reasonable assumption of a -0.4 for total demand elasticity of corn, 1.5 to 3.0 cents would be added to the market price of corn. This increase translates into an annual increase of $100 to $225 million dollars of income to U.S. corn producers. Note, the bushels of corn utilized would increase if the range of products was extended beyond packaging and/or if advances in technology increased the percent of starch which could be incorporated into biodegradable plastics while maintaining desired product characteristics and economic competitiveness.

Biodegradable plastics, photodegradable plastics, and recycled plastics will not solve the landfill problem because plastics make up only about 30 percent of the volume of current landfill waste, but they can

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[1] The 25-30 million bushel estimate is derived as follows: (1) 14 billion lbs. of resin x 6% = 840 million lbs. of corn starch; (2) 840 million lbs/31.5 lbs of starch per bu. of corn = 27 million bu. (Corn starch yield is taken from reference 24, pp. 59)

extend the life of current landfills. Degradable plastics could enhance the feasibility of composting operations by being used as receptacles for organic waste. Food waste and yard waste make up about 30 percent of the non-reclaimed products discarded into the municipal waste stream (1, pg. 202). If a third of the current waste could be composted or be degraded in a relatively short period of time, the expected life of a landfill could theoretically be extended by about 50 percent.

Recycling appears to buy the most time because biodegradable and photodegradable plastics still require landfill space to degrade. At a landfill charge of $100 a ton, one could theoretically spend five cents per pound of plastic for recycling operations and still break even from the perspective of foregone landfill charges. Recycling of plastics will also benefit from a competitive spinoff as more and more state and local governments require recycling of all types of waste.

Research is needed to improve the economic competitiveness of degradable and recycled plastics and to extend their use to other product areas. Research is also needed to improve the predictability of degradation in landfills. Attaining this goal will buy more time for existing landfill space.

Society can in effect dictate that private firms conduct research on these issues by restricting the use of conventional plastics and/or mandating the use of new types of plastics. This type of research is spurred by market defense strategies. On the other hand, society can encourage research by providing matching funds for private research or by funding public research. This type of research is more akin to market development strategies. So far, society has generally chosen to use restriction/regulation--the "stick"--rather than financial support for research--the "carrot." A greater balance between carrots and sticks may provide a more satisfactory, not to mention more rapid, resolution of the plastic waste dilemma.

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